

PERFORMANCE INVESTIGATION AND EXHAUST ANALYSIS OF C.I ENGINE FUELLED BY DIESEL MIXED WITH JAMUN SEED POWDER AND JACK FRUIT SEED POWDER

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ABSTRACT

Diesel prime movers are the dominating sources of air pollution. Plenty of trials are going on to overcome this issue, but still, it's a challengeable task to replace fossil fuel completely, because of its peculiarity. In this experimental work, an attempt is made to check deviation in performance and emissions of diesel fuel by adding jamun seed powder and jack fruit seed powder, directly. Two different samples have been prepared on mass basis and named as JJS-1 and JJS-2. Test is conducted on computerized single cylinder, water cooled diesel engine with pure diesel, JJS-1 and JJS-2 at different loads. JJS-1 sample performance characteristics are slightly improved at half load and almost equal to diesel at higher load. Positive impression has been observed in emissions, which are observed as considerable reduction in NO_x and JJS-2 sample has not given any observable positive results. The future scope of the work can be further extended at different speeds and compression ratios.

KEYWORDS: Prime Movers, Pollution, Jamun Seed Powder, Jack Fruit Seed Powder & No_x.

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NOMENCLATURE

- JJS-1 : Jack fruit & Jamun seed powder sample-2(Sample-1).
- JJS-2 : Jack fruit & Jamun seed powder sample-2(Sample-1).
- BP : Brake power.
- BSFC : Brake specific fuel consumption.
- BThE : Brake thermal efficiency.
- ME : Mechanical efficiency.
- EGT : Exhaust gas temperature.
- CO : Carbon monoxide.
- CO₂ : Carbon dioxide.
- HC : Hydrocarbons.
- NO_x : Oxides of nitrogen.
- Ppm : Parts per million.

INTRODUCTION

Efforts to replace diesel is an upcoming trend and challengeable too. Diesel emission is linked up with harmful results on environment and also on human beings [1]. Urban cities are more likely to suffer from passenger vehicles during traffic and Euro norms are not implemented strictly [2]. Improvement in freight policies and implementation of emission standards nationwide in time will impact greatly on pollution control [3]. In this regard, biofuel program encourages improving oil seeds, which contributes majorly in the preparation of alternative sources to replace fossil fuel [4]. Biofuels and natural gas proved their potentials in reducing greenhouse gases compared to conventional fuels [5]. Use of biodiesels in diesel engines have showed improved performance, which directly depends on selection of feedstock and engine operating conditions. Production of biodiesel has many barriers like limited raw materials, cost of manufacturing, increased CO₂ and NO_x made us to divert for microalgal and electro bio fuels [6, 7]. *Eugenia jambolana* seed and jack fruit has rich antioxidant property [8, 9, 10, and 13] which may help us to control NO_x. Compared to seed and pulp of jamun, leaves are having more antioxidant properties [11]. It is observed that at low temperature, antioxidant characteristics of squash or jam of jamun were increased [12]. Usage of jamun seed oil biodiesel was given almost equal brake thermal efficiency, but increased NO_x and HC emissions observed [14]. The mixture of orange peel and jamun seed powder added to diesel were proved ineffective in reducing oxide formations [15]. Cotton seed and neem oil biodiesel, mixed with cerium oxide showed lower emissions of oxides and specific fuel consumption decreased with increase in load [16]. Performance of diesel engine is improved and emissions are reduced, when jamun seed oil biodiesel is blended with diethyl ether [17]. Papaya seed methyl ester mixed with n-butanol have given notable positive results of performance and decrease in HC, CO emissions, but NO_x emissions increased at higher load because of high oxygen content in fuel [18]. Mixing of biodiesel have proven performance, but negatively impacted on emissions of high speed engines. Pure honge biodiesel has given performance equal to diesel, whereas mixing of biodiesel with diesel in 20% and 40% proportion has given performance higher than pure diesel [19, 20]. In the use of biodiesel with compressed natural gas under dual mode, it is observed that there is reduction in NO_x but increased CO and HC emissions [21]. Diesel and biodiesel blend with additives have given more performance than pure diesel and also reduces fuel consumption as well as emissions [22]. Improvement in the performance is only not the prime concentration, simultaneously, we have to focus on emissions and fuel economy. In this research work, we are mixing raw organic seed powder of two different antioxidant enriched fruits. Based on mass proportions, we have prepared two samples which were tested on stationary direct injection diesel engine.

MATERIALS AND METHOD

Preparations of Samples and Properties

Jack fruit seeds and jamun seeds are purchased from local vendors of Nellore town, and then made them completely dry in sunlight for 8 days to ensure that no moisture is present (Figure 1 & Figure 2).



Figure 1: Jack Fruit Seed



Figure 2: Jamun Fruit Seed

Dried seeds are then roughly crushed in cloth cover, and then transferred to kitchen grinder to make it fine powder. Then, it is filtered to remove unwanted, uncrushed fibers and particles. Prepared powders are weighed by using electronic weighing machine with two different proportion, 15 grams of jack fruit seed powder and 15 grams of jamun seed powder for sample JJS-1. Similarly, 25 grams of jack fruit seed powder and 25 grams of jamun seed powder for sample JJS-2(Figure 3 & Figure 4).



Figure 3:Jack Fruit Seed Powder



Figure 4: Jamun Seed Powder

Standard diesel is mixed with weighed powders as per required proportion (Table-1) and stirred well manually, so that it blends properly. The mixed samples are stored separately for 5 days in air tight bottles. Then samples are filtered carefully, so that no seed powder particles leftover in diesel. Then samples are tested for different fuel properties, which are listed in table-2.

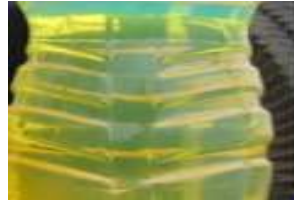
Figure 5 and figure 6 shows the final prepared sample, which can be clearly differentiated by color of the samples. Pure diesel is pale green and sample(s) color is pale yellow.

Table 1: Composition of Samples on Mass Basis

Sl. No	Sample Name	Diesel (gm.)	Jack fruit Seed Powder (gm.)	Jamun Seed Powder (gm.)
1	JJS-1	870	15	15
2	JJS-2	850	25	25

Table 2: Properties of Diesel, JJS-1 and JJS-2.

Fuel property	Diesel	JJS-1	JJS-2
Density (kg/cm ³)	835	860	848
Kinematic Viscosity(cSt)	2.59	1.2	1.34
Flash Point(⁰ C)	56	68	72
Calorific Value (kJ/kg)	43200	41212.4	40940.4

**Figure 5: Pure Diesel****Figure 6: Sample JJS-1 & JJS-2**

Engine Test Rig and Exhaust Analyzer

Performance test and emission analysis were done on stationary single cylinder - direct injection computerized diesel engine, present in the laboratory of thermal science, KONERU LAKSHAMAIAH EDUCATION FOUNDATION, Guntur district, A. P. Detailed engine specifications are tabulated in table 3. Performance parameters were automatically generated through computer interface, and emission readings were taken by Indus 5 gas analyzer (Figure 7 represents exhaust gas analyzer).

Table 3: Engine Specification

Parameters	Specifications
Make	Kirloskar Oil Engines, INDIA.
Type	Naturally aspirated direct injection, water cooled four stroke single cylinder.
Bore(mm)	80
Stroke(mm)	110
Rated Power(KW)	3.7
Rated speed (RPM)	1500
Compression ratio	16:1
Loading	Electrical loading, single phase 230 V, 22 A.

Computerized Engine-dynamometer test rig is a kit attached to computer, through which readings can be interfaced. (Figure 8 represents computerized test rig).



Figure 7: Indus Exhaust Gas Analyzer



Figure 8: Computerized Engine Test Rig

The layout of Experimental Setup (figure 9) is as shown below

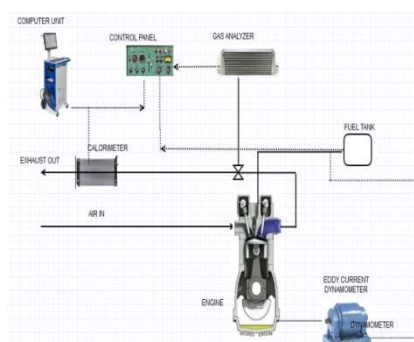


Figure 9: Layout of Experimental Setup

Test Procedure

Performance test and emission analysis were carried with diesel, JJS1 and JJS2. Initially, we have calibrated the parameter capturing unit and gas analyzer instrument, by keeping standard readings as references. First test was conducted with pure diesel at constant speed and at various loads. Readings of pure diesel at the range of load 0%, 25%, 75% and 90% were captured using computer interface data acquisition system by maintaining the gap of 15-20 minutes between each load. For second test, fuel tank is completely evacuated and allowed to dry then tank is filled with JJS1, engine is started and allowed to run for 20 minutes at zero loads to ensure that any spill diesel in the fuel line to be completely consumed. Now, engine is allowed to cool and return to initial condition, by keeping water flow rate on. Now, the set up is ready to take readings for sample JJS1. Repeat the procedure as done for diesel, to take set of readings from no load to full load. For final test, same procedure will be followed as like above. For all three tests, emission readings are noted from gas analyzer at respective loads.

Care must be taken that, logging of readings at different loads through computer interface can be done after reaching the steady state of engine.

RESULTS AND DISCUSSIONS

After obtaining flawless readings, performance curves BThE, ME, BSFC, EGT were drawn at various loads. Similarly, emissions at various loads are analyzed.

PERFORMANCE CHARACTERISTICS

Brake Thermal Efficiency

Figure 10 gives performance curves drawn by taking BThE versus BP. Brake thermal efficiency obtained by pure diesel and sample JJS-1 are almost equal at low load and high load, but slight increase is observed at half load. Sample JJS-2 has given positive results initially, but notable decreased at higher load.

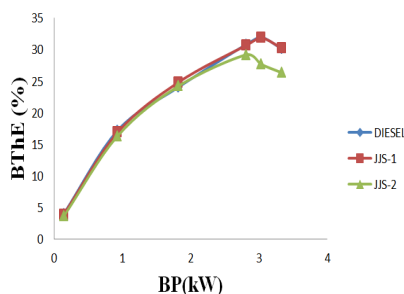


Figure 10: BThE Versus BP.

Brake Specific Fuel Consumption

Figure 11 gives specific fuel consumption at various loads. It is seen that at lowload, engine consumes more fuel of sample JJS-2 and JJS-1 compared to diesel but at high load, diesel and JJS-1 curves are overlapping with diesel. Considerable change in calorific value might be the reason. At higher load, it is noticed that there is remarkable increase in JJS-2 fuel consumption, as it is having low calorific value.

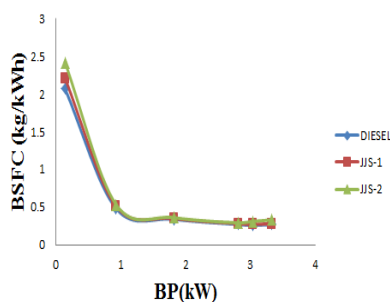


Figure 11: BSFC Versus BP

Mechanical Efficiency

Figure 12 indicates mechanical efficiencies obtained for all three fuels at various loads and constant speed. It is seen that up to 70% of load, JJS-1 given higher mechanical efficiency than diesel and slightly decreased at higher load, this is because, at lower load indicated power for JJS-1 is more as compared to diesel, this is justified through high JJS-1 fuel consumption also. Sample JJS-2 has given negative results till 75% of load, and then it nearly equals to JJS-1, but again decreased at higher load. This deviation is result of difference between fuel properties as well as fuel flow rate.

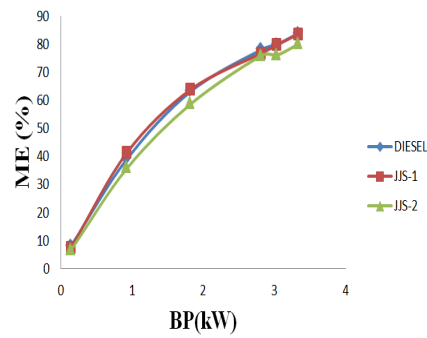


Figure 12: Mechanical Efficiency Versus BP

Exhaust Gas Temperature

Figure 13 indicates variation of exhaust temperature from no load to full load. It is seen that exhaust gas temperature of JJS-1 is less, compared to diesel and JJS-2. At low load, EGT is less and as load increases, it tends to reach diesel value. For JJS-2, EGT is nearly equal to diesel at lower load and increases with load.

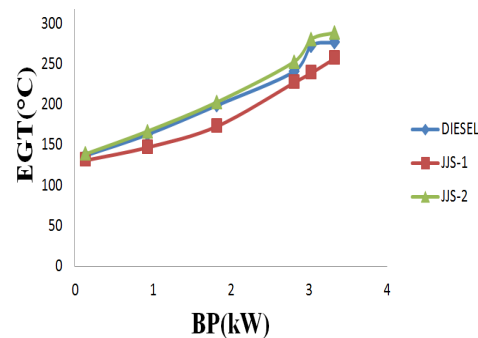


Figure 13: EGT Versus BP

EMISSION ANALYSIS

Variation of CO (in %)

Figure 14 shows variation of carbon monoxide at various load and constant speed. From graph, it is observed that JJS-1 and JJS-2 both samples are having more CO emissions at lower load but at half load, JJS-1 given less CO. As load increases, CO value for JJS-1 increases, and at higher load, it is almost equal with diesel. For sample, JJS-2 CO emission is high at all loads compared to diesel and JJS-1. It is also noted that for JJS-2, CO emission decreases randomly, as load increases, and it is much more deviated at higher load.

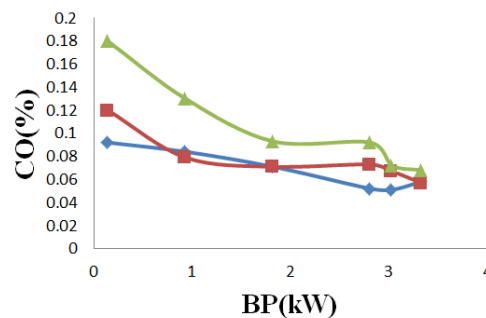


Figure 14: CO Versus BP

Variation of CO₂ (in %)

Figure 15 indicates CO₂ variation at different brake powers. From figure, it is noted that JJS-1 has given slightly higher CO₂ at lower load compared to diesel, and at 25% load, it is overlapping with diesel curve. As load increases, much more deviation is found. Sample JJS-2 has given much higher CO₂ emission from no load to full load, but at 75% of load, JJS-1 and JJS-2 both have coincided.

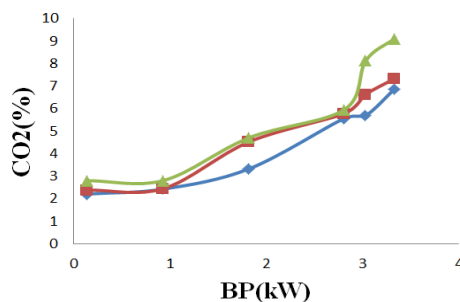


Figure 15: CO₂ Versus BP

Variation of HC (ppm)

Figure 16 shows variation of HC with load. From figure, it is clear that JJS-1 has higher HC at lower load, but coincided with diesel at 75% of load and decreased at higher load. Sample JJS-2 given lower HC compared to JJS-1 at low load and increased with load. As the engine capacity is same and fuel consumption is more in case JJS-2 and JJS-1, this will lead for high HC compared to diesel.

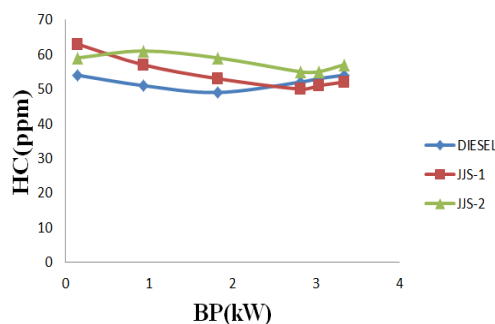


Figure 16: HC Versus BP

Variation of NO_x (ppm)

Figure 17 gives variation of oxides of nitrogen with load. This was an important parameter, where we have focused, because of antioxidant nature of jackfruit seed and jamun seed powder. From figure, it's noted that there is remarkable decrement in NO_x of JJS-1 at higher load, but it is almost equal to diesel, up to half load. JJS-2 has given negative results at all loads. This is because of EGT of JJS-1, which is less compared to diesel and JJS-2.

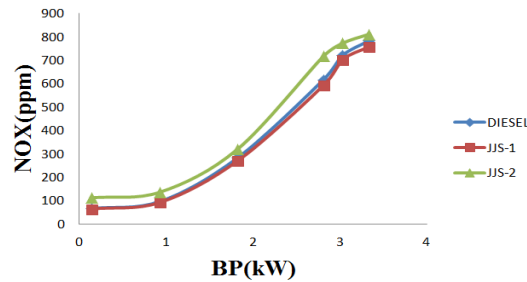


Figure 16: NO_x Versus BP

CONCLUSIONS

From all above data and graphs, the following points are concluded:

- JJS-1 has improved brake thermal efficiency and mechanical efficiency at moderate loads, and it is almost equal to diesel at higher load.
- BSFC of JJS-1 at lower load is high, but as load increases it is overlapped with diesel curve.
- Less EGT of JJS-1 which leads to reduce NO_x at higher load.
- JJS-1 has given less CO emissions at half load and less HC emissions at full load.
- JJS-1 and JJS-2 both sample CO₂ readings are higher than diesel at all loads.
- No positive results were obtained from JJS-2 in any performance and emission analysis.
- So, from all above discussions, it is summarized that sample JJS-1 has given good performance and less NO_x at certain conditions, which made us to think over to extend this work, so that optimum results can be framed.

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